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# USSR Report

## PHYSICS AND MATHEMATICS

No. 74

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## CONTENTS

ACOUSTICS

Planar Acoustic Wave Scattering by Two Ideal Spheres..... 1

Sound Damping Due to Decay of Coherent Concentration Waves in Niobium-Hydrogen Solution..... 1

Sound Propagation in Crystallizing Liquid..... 2

Miniature Hydroacoustic Receivers Based on Discrete Structures.... 3

CRYSTALS AND SEMICONDUCTORS

Ultrahigh-Vacuum Equipment for Complex Study of Surfaces and Ultrathin Solid Films..... 4

Using Ellipsometry To Determine Thickness and Refractive Index of Very Thin Dielectric Films..... 5

Effect of Quantum Corrections on Resistance of Thin Bismuth Films..... 5

Surface Polaritons in Ion-Implanted Gallium Arsenide..... 6

Electric Conductivity of Cesium Iodide Behind Shock Wave Front at Pressures Up to 100 GPa..... 7

Defects Produced by Silicon Ion Implantation in p-Silicon Close to Si-$SiO_2$ Interface..... 7

Effects Accompanying Strong Sound Wave in Piezoelectric Semiconductor..... 8

ELECTRICITY AND MAGNETISM

Using Homogeneous Magnetic Fields for Electron Beam Bunching..... 9

Dynamic Characteristics of Electric Arc in Rotating Magnetic Field and Problems of Stability of Arc Burning..... 10

Effect of Normal Cathode Current Density on Stability of Semi-Self-Maintained Glow Discharge..... 10

FLUID DYNAMICS

Propagation of Shock Waves Through Widening Channels..... 12

Aerodynamic Forces on Rough Rotating Cylinder in Transverse Flow..... 12

Motion of Viscous Fluid Along Traveling Wave at High Subcritical Reynolds Numbers..... 13

Frequency Characteristics of Normal Waves in Shallow Sea With Laminar Absorbing Bottom..... 14

LASERS AND MASERS

Dynamic Compensation of Optical Inhomogeneities in Iodine Laser..... 15

Effect of Stimulated Raman Scattering on Emission Characteristics of Solid-State Ring Laser..... 15

Determining Gain of Molecular Lasers From Characteristics of Noncoherent Infrared Radiation..... 16

Emission of Coherent Radiation by Beam of Relativistic Electrons in Undulator..... 16

Using Magnetic Field To Control Position and Width of Unidirectional Emission Region in Ring Gas Laser..... 17

Emission Frequency Splitting in Ring Laser With Rectangular Diaphragm, Part IV..... 18

Spatial Filtration of Apodized Laser Beams..... 19

Refinement of Vibrational Temperature Model for Describing Emission Characteristics of Short-Pulse $CO_2$-$N_2$-He Laser..... 19

Influence of Oxygen on Nitrogen Laser Emission..... 20

Characteristics of Carbon Monoxide Gas-Discharge Overtone-Laser: I. Steady State..... 21

Thermal Conditions of the Light Generating System Optical Elements in Solid-State Laser With Natural Cooling..... 21

MOLECULAR PHYSICS

Electron-Beam Diagnosis in Nitrogen: Secondary Processes..... 23

Investigation of 'Fast' Heating of Oxygen in Non-Self-Maintained Discharge..... 24

NUCLEAR PHYSICS

Acceleration of Electron Beam in Array of Radial Lines Excited by External Pulse Generator..... 25

Intense Pulsed Electron Beam Generation in Moderate-Density Gas..... 25

Spontaneous Shortwave Emission by Intense Electron Beam..... 26

Filamentary Structure of Tubular Relativistic Electron Beam..... 27

Trapped Alpha-Particle Magnetoacoustic Instability in Tokamak With Elliptical Cross Section..... 28

Brillouin Electron Flow Instability..... 28

Nonlinear Energy Principle and Kink Instability of Compact Torus..... 29

Optimizing Systems for After-Acceleration of Intense Charged Particle Fluxes..... 29

OPTICS AND SPECTROSCOPY

Static and Dynamic Three-Dimensional Holograms..... 30

Superluminescence Spectral Behavior..... 30

Laser Mirrors for Far XUV..... 31

Optical Bistability and Hysteresis in Four-Beam Wavefront Reversal in Ferroelectrics..... 32

Suppressing Effect of Small-Scale Self-Focusing With Beam Rotation, Jitter or Wobble..... 33

Fast-Action Automated System for High-Temperature Measurements (2500-6000 K) With Heating by Laser Emission..... 33

OPTOELECTRONICS

New Experimental Results on Effective Use of Random-Phase Mask in Holographic Memories..... 35

Reconstructing Complex Field Amplitude of Object Observed Through Optically Inhomogeneous Random Medium..... 36

Box-Like Electrostatic Lens With Four Planes of Symmetry..... 36

Resolution of Polarization-Type Electro-Optical Deflector..... 37

Particulars of Ultrashort Intense Light Pulse Propagation in Multimode Optical Fibers..... 38

PLASMA PHYSICS

Explosive Model of Arc-Discharge Cathode Spots..... 39

Longitudinal Wave Amplification in Modulated Beams: I. Fundamental Harmonic Amplification..... 39

Heat Transfer in Turbulent Laser Plasma..... 40

Resonant Interaction of Plasma Beam With Exchangeless Magnetostatic Surface Wave..... 41

Nonlinear Saturation of Stimulated Mandelstam-Brillouin Scattering in Rarefied Nonisothermal Plasma..... 41

Scientific-Engineering Approach to Problem of Modeling and Analyzing Plasmotron Dynamics as Technological Object: III. Analysis of Dynamics in Case of Distributed External Factors, Method of Dynamic Plasmotron Optimization..... 42

Calculating Limiting Energies of Gas-Discharge Flashlamps..... 43

Definition of Strongly Nonideal Plasma..... 43

Model of Quasisteady Heavy Inert Gas Beam Plasma: I. General Description of Model..... 44

SUPERCONDUCTIVITY

Effect of $Ar^+$ and $O_2^+$ Ion Injection on Superconducting Properties of Niobium Films..... 45

THERMODYNAMICS

Approximate Solution of Heat Conduction Problem in Presence of Moving Heat Source..... 46

UDC 534.26

## PLANAR ACOUSTIC WAVE SCATTERING BY TWO IDEAL SPHERES

Minsk IZVESTIYA AKADEMII NUAK BSSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK in Russian No 4, Jul-Aug 81 (manuscript received 3 Sep 80) pp 5-10

MARNEVSKAYA, L. A., Institute of Mathematics, BSSR Academy of Sciences

[Abstract] The author solves the problem of diffraction of a plane sound wave for two spheres when one is acoustically soft, and the other is acoustically hard. It is assumed that the spheres are located in an infinite homogeneous medium and have arbitrary given radii. The planar acoustic wave propagates from a source on the line joining the centers of the two spheres at a point midway between them in a direction at a given angle to this line. The potential of the scattered sound wave is found that satisfies the Helmholtz wave equation in the region outside of the spheres, boundary conditions on the surfaces of the spheres and the condition of radiation at infinity. The solution is found by separation of variables, giving infinite systems of linear equations with matrix elements in the second members. An asymptotic expression is used to find an approximation for the scattered field in the far zone. Computer-generated numerical solutions are given for the scattering intensity in the far zone in the case of two spheres of identical radius separated by different distances, and also for a fixed distance and fixed radius of one sphere as the radius of the other sphere is varied. Figures 4, references 4 Russian.
[18-6610]

## SOUND DAMPING DUE TO DECAY OF COHERENT CONCENTRATION WAVES IN NIOBIUM-HYDROGEN SOLUTION

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 34, No 6, 20 Sep 81 (manuscript received 15 Jul 81) pp 338-341

MELIK-SHAKHNAZAROV, V. A., NASKIDASHVILI, I. A. and ARABADZHYAN, N. L., Institute of Physics, Georgian SSR Academy of Sciences

[Abstract] Previous research has shown that decay of metal-hydrogen solid solutions involves the formation of planar concentration waves on the macroscopic

scale with wavelength of the order of specimen dimensions, and on the microscopic scale with wavelength much smaller than specimen dimensions. Cold neutron scattering experiments on the stability limits of short-wave concentration waves in Nb-H solid solution have shown two spinodals lying below a temperature of 80 K corresponding to two orientations of the wave vector $\vec{\kappa} \parallel [110]$ and $\vec{\kappa} \parallel [111]$. In this paper the authors study damping of sound on about 1000 Hz in a solid solution of $NbH_{0.04}$ in the temperature range of 1.5-80 K that includes the temperatures of the two spinodals for the given composition. The specimens were plates measuring 10 x 3 x 0.3 mm in which the transverse 1/4-wave mode was excited. The measurements were done with an acoustic spectrometer working in the regenerative mode. Zone-melted polycrystal niobium was used. Hydrogen saturation was done at 850 K in a quartz vessel. Maxima in attenuation of sound were observed at 18 K and 55 K, which are the spinodal temperatures for the given composition, which means that the observed absorption maxima are due to loss of stability of the concentration waves polarized in directions [110] and [111]. An estimate of the coefficient of diffusion of hydrogen gives $D \gtrsim 10^{-11}$ cm$^2$/s at 20 K. Despite the high concentration of hydrogen, this coefficient of diffusion is 3-5 orders of magnitude higher than those determined by other methods. Figure 1, references 12: 5 Russian, 7 Western.
[36-6610]

UDC 534.833.53:532.872

## SOUND PROPAGATION IN CRYSTALLIZING LIQUID

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 27, No 5, Sep-Oct 81
(manuscript received 20 May 81) pp 678-686

AKULICHEV, V. A. and BULANOV, V. N., Pacific Oceanological Institute,
USSR Academy of Sciences

[Abstract] An analysis is made of the propagation of sound in a crystallizing liquid with determination of the relative contributions of various mechanisms to excess absorption and dispersion of the speed of sound. An examination is also made of the influence that impurities have on sound propagation in a crystallizing liquid. It is shown that the absorption of sound in a crystallizing liquid is greater than that in a liquid with solid particles without phase transitions. This apparently explains the intensification of acoustic currents in crystallizing melts. The dispersion of the speed of sound in a crystallizing liquid is also anomalously high as compared with a liquid that contains solid particles without phase transformations. Experiments to confirm these effects should be done at fairly low sound frequencies, and at as high a volumetric concentration of solid phase as possible. Of particular interest would be a study of sound propagation in slush ice, since such a medium may have an appreciable effect on the conditions of propagation of acoustic signals in polar regions of the ocean. Figures 4, references 17: 15 Russian, 2 Western.
[30-6610]

UDC 681.883.67:534.232

# MINIATURE HYDROACOUSTIC RECEIVERS BASED ON DISCRETE STRUCTURES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 27, No 5, Sep-Oct 81
(manuscript received 30 Apr 80, after revision 19 Feb 81) pp 759-766

KONEVA, M. A., KRAVCHUN, P. N. and CHERNYSHEV, K. V., Moscow State University imeni M. V. Lomonosov, Acoustics Department

[Abstract] The problem of making low-frequency transducers with dimensions smaller than a wavelength can be solved by using oscillatory systems with lumped parameters. One such design in hydroacoustics is a compound dipole in which the elasticity is provided by a piezoelectric element, while the mass takes the form of passive end plates on this element. In such a system, the resonant frequency can be lowered only by increasing the dimensions of the passive component. Another system that can be treated as a resonator with lumped mass and elasticity is based on utilizing resonance in a passive system of two transitional layers of small thickness. Such a system has small dimensions in the direction perpendicular to the working surface of the transducer, and can act as a single-frequency matching dipole. In this paper the authors stude a method of making miniature transducers that differ from conventional designs in using discrete (generally speaking multiple-link) structures in which the inertial elements are piezoactive. An increase in compliance of the elastic elements of such a structure without changing the mass of the active inertial elements or the overall dimensions can in principle arbitrarily reduce the velocity of wave propagation in the structure. The analysis is based on a model with two degrees of freedom made up of two components: the first is a reception plate of given mass and area with an elastic spring, and the second is a piezoelectric element of given mass and length and another elastic spring. The element has the longitudinal piezoelectric effect, and voltages are taken off at the plates. The characteristics for the reception mode are analyzed. Calculations of sensitivity are confirmed by experiments. Figures 4, references 7 Russian.
[30-6610]

UDC 533.599

# ULTRAHIGH-VACUUM EQUIPMENT FOR COMPLEX STUDY OF SURFACES AND ULTRATHIN SOLID FILMS

Riga IZVESTIYA AKADEMII NAUK LATVIYSKOY SSR: SERIYA FIZICHESKIKH I TEKHNICHESKIKH NAUK in Russian No 4, Jul-Aug 81 (manuscript received 14 Jan 81) pp 122-125

BERGS, A. B., KALNACH, Ya. V., KVASKOV, L. V. and FELTYN', I. A., Physico-Energetics Institute, LaSSR Academy of Sciences

[Abstract] An ultrahigh-vacuum test stand has been developed suitable for complex studies of surfaces and ultrathin solid films, with facilities for adaptation of the equipment components to any specific task. It consists of three main functional parts: a transfer chamber where a vacuum of $(5-8)\cdot10^{-8}$ Pa can be attained within 30 min with the aid of two sorption pumps and one magnetic-discharge pump, for preparation of a specimen, a working chamber where the vacuum is initially $1\cdot10^{-7}$ Pa and can drop to $1\cdot10^{-8}$ Pa for processing and rough testing of a specimen, and the test chamber proper where the vacuum is at least $10^{-8}$ Pa. Auxiliary components include an ellipsometer chamber with an LEF-2 instrument, a sprayer chamber, an ion gun, an electron gun, a vacumeter probe, a mass-spectrometer probe, a set of metal-glass vacuum-sealed voltage (0-12 kV) and current (0-100 A) feeders, a gas feed line, a liquid-nitrogen feed line, a set of specimen manipulators, a set of inspection windows, and a set of irradiation windows made of quartz and sapphire. The ion gun produces ion beams with an energy of 100-600 eV and a density of $10^{-3}$ mA/m$^2$ under a gas pressure of $10^{-1}$ Pa. The electron gun with an accelerating voltage of 1-7 kV produces electron beams with a density of $4\cdot10^{-3}$ mA/m$^2$ for heating and cleaning a specimen. The working chamber is evacuated by means of two zeolite sorption pumps, a magnetic-discharge pump, and a titanium evaporation pump. The main advantages of this equipment are its universality, mobility and flexibility, also the possibility of shielding a specimen against atmospheric effects. Figures 2, references 4 Russian. [25-2415]

UDC 53:51-539.216.2

## USING ELLIPSOMETRY TO DETERMINE THICKNESS AND REFRACTIVE INDEX OF VERY THIN DIELECTRIC FILMS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 9, Sep 81 (manuscript received 22 Jul 80) pp 1928-1932

KRASIL'NIKOVA, Ye. V. and LEBEDEVA, V. N., Institute of Crystallography, USSR Academy of Sciences, Moscow

[Abstract] A computer experiment is done on use of the least-squares method in the film and backing problem for thin films of water (n = 1.3318) on LiF backings (n = 1.39119) and on YAG backings (n = 1.8305) at wavelength $\lambda$ = 6328 Å. First a solution was found for the direct problem: determining the parameters $\psi$ and $\Delta$ from the Drude equation at known constants of the backing and film. The resultant pairs of "experimental" values $\psi_i^e$ and $\Delta_i^e$ calculated at three angles of incidence $\phi_i$ were then used as initial data in solving the inverse problem: determining the parameters n and d of the film from the given $\psi_i^e$ and $\Delta_i^e$. An analysis of the way that the solution depends on the initial estimates of the unknown index of refraction and thickness of the water film, as well as analysis of the permissible errors in the experimental parameters $\psi$ and $\Delta$ shows that simultaneous determination of n and d is possible for thin films down to about 10 Å thick when the refractive indices of film and backing are considerably different (water and garnet), but fails for close indices (water and LiF) at thicknesses of less than 40 Å. Figures 3, references 6: 3 Russian, 3 Western.
[20-6610]

## EFFECT OF QUANTUM CORRECTIONS ON RESISTANCE OF THIN BISMUTH FILMS

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 34, No 6, 20 Sep 81 (manuscript received 31 Jul 81) pp 367-371

SAVCHENKO, A. K., LUTSKIY, V. N. and RYLIK, A. S., Institute of Radio Engineering and Electronics, USSR Academy of Sciences

[Abstract] Recent theoretical research has examined quantum corrections to the resistance of thin metal films. It has been shown that interference of electron waves when they are scattered by impurities leads to an anomalous rise in resistance as temperature falls (theory of "localization"). In an alternative theory (the theory of "interaction") an anlogous result comes from consideration of the interaction between electrons as they are scattered by impurities. Both theories give the same law of logarithmic increase in film resistance as the temperature decreases:

$$\frac{\Delta R_\square}{R_\square^2} = -\frac{\alpha p}{2}\frac{e^2}{\pi^2 \hbar}\ln T,$$

where $R_\square$ is the resistance of a film of square shape. In the theory of localization the parameter $\alpha \sim 1$, and the parameter p is determined by the mechanism of

inelastic scattering and lies in a range of 2-3. In the theory of interaction $\alpha p \sim 1$, and may be less than unity in the case of strong shielding. In studies of the effect of magnetic field on quantum corrections to conductivity the difference between the theories shows up in the way that anomalous magnetoresistance depends on the magnetic field: with the exception of a few specific situations, this dependence is negative for the theory of localization and positive for the theory of interaction. Some experiments show a logarithmic increase in the resistance of thin films of metals as T decreases, which can be attributed to localization of electrons. In other experiments, the predominant role of interaction between electrons in metal films is observed. In this paper the authors study the influence of quantum corrections on the resistance of thin films of bismuth produced by vacuum sputtering on mica at room temperature. Thicknesses ranged from 50 to 500 Å. Resistance was measured by a compensation method on alternating current at a frequency of 20 Hz, ensuring a sensitivity of $10^{-5}$. The voltage across the specimens was about 1 mV. The results of measurements show logarithmic increase in resistance with decreasing temperature and logarithmic dependence of magnetoresistance on magnetic field. It is concluded that the observed behavior is due to predominant influence of effects of interelectron interaction. Figures 3, references 8: 5 Russian, 3 Western.
[36-6610]

SURFACE POLARITONS IN ION-IMPLANTED GALLIUM ARSENIDE

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 23, No 9, Sep 81
(manuscript received 23 Feb 81) pp 2630-2633

DMITRUK, N. L., LITOVCHENKO, V. G. and NIKOLAYEVA, T. N., Institute of Semiconductors, UkSSR Academy of Sciences, Kiev

[Abstract] An ATR technique is used to study the effect of $Si^+$-ion doping of semi-insulating GaAs. Implantation was with ions of 80-keV energy in doses of from $5 \cdot 10^{12}$ to $10^{13}$ $cm^{-2}$. Some of the specimens were annealed at 650-700°C without protective coatings to activate the dopant and anneal the defects introduced by implantation. The external-reflection and ATR spectra were measured in the region of lattice vibrations. The measurements were done on the IKS-21 spectrometer with ATR attachment based on a CsI dispersing element in the form of a semicylinder. The results are interpreted on the basis of a multilayer model of the reflecting system including the surface layer in which surface plasmon-phonon polaritons are localized. Analysis shows that the measurement of ATR spectra is a quite effective nondestructive method of ion-doped semiconductors (concentration and mobility of current carriers, frequency and attenuation of phonons). Figures 2, references 17: 10 Russian, 7 Western.
[35-6610]

ELECTRIC CONDUCTIVITY OF CESIUM IODIDE BEHIND SHOCK WAVE FRONT AT PRESSURES UP TO 100 GPa

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 23, No 9, Sep 81
(manuscript received 17 Dec 80, after revision 11 May 81) pp 2848-2851

GATILOV, L. A. and KULESHOVA, L. V.

[Abstract] One of the few currently accessible techniques for studying the state of matter at high pressures and temperatures is the measurement of electric conductivity of condensed media in shock waves. However, there have been procedural difficulties in measurement of electrical conductivity close to metallic in shock-compressed dielectrics. In this paper, the authors use a method that overcomes these difficulties [see L. A. Gatilov, L. V. Kuleshova, ZHURNAL PRIKLADNOY MEKHANIKI I TECHNICHESKOY FIZIKI, No 1, 1981, p 136] to measure the electrical conductivity of cesium iodide behind a shock wave front. The conductivity distribution was determined for CsI single crystals behind a planar steady-state shock wave front. It was found that conductivity increases from 10 to $10^5$ mho/m as pressure rises from 20 to 100 GPa. Conductivity falls off with time of the CsI in the compressed state in the solid phase, and increases in the liquid phase. This behavior shows the nonequilibrium nature of CsI behind the shock wave front for times greater than the measurement time of about 0.5 μs. A qualitative interpretation of the experiment is given, based on the assumption of gradual conversion of CsI with increasing shock wave amplitude to an intrinsic-defect semiconductor, and subsequently to a liquid semiconductor and a liquid metal. Figure 1, references 16: 15 Russian, 1 Western. [35-6610]

UDC 621.315.592

DEFECTS PRODUCED BY SILICON ION IMPLANTATION IN p-SILICON CLOSE TO Si-$SiO_2$ INTERFACE

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 15, No 9, Sep 81
(manuscript received 4 Dec 80) pp 1755-1759

GALKIN, G. N., VAVILOV, V. S., ABBASOVA, R. U. and BOBROVA, Ye. A.,
Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] The method of capacitance-voltage curves of MDS structures is used to determine the position of deep levels created by implanting silicon ions in silicon close to the Si-$SiO_2$ interface through a layer of $SiO_2$. Curves are plotted for the defect concentration as a function of implantation dose and annealing temperature. Plates of thermally oxidized p-Si were used that were grown by the Czochralski method with resistivity of 15 Ω·cm and oxide thickness of 1100 A. Implantation of $^{30}Si^+$ ions with energy of 120 keV took place in the vicinity of the Si-$SiO_2$ interface. Ion doses were from $10^{11}$ to $10^{13}$ ions/$cm^2$. The specimens were annealed in argon from room temperature up to 510°C.

Measurement of capacitance-voltage characteristics showed deep levels due to implantation defects at $E_c$-0.25, $E_c$-0.4, $E_c$-0.52, $E_v$+0.44, $E_v$+0.38 and $E_v$+0.26 eV. The results show bimolecular annealing of the continuous background of the density of states on the Si-$SiO_2$ boundary. Figures 4, references 12: 3 Russian, 9 Western.
[31-6610]

UDC 621.315.592

EFFECTS ACCOMPANYING STRONG SOUND WAVE IN PIEZOELECTRIC SEMICONDUCTOR

Leningrad FIZIKA I TEKHNIKA POLUPROVODNIKOV in Russian Vol 15, No 9, Sep 81 (manuscript received 28 Dec 78, after revision 9 Feb 81) pp 1823-1826

CHERNOZATONSKIY, L. A.

[Abstract] When a strong acoustic wave propagates in a piezoelectric semiconductor in the region of wavelengths exceeding the effective mean free path of electrons, the electron density wave that accompanies the sound becomes nonsinusoidal due to strong concentrational nonlinearity. In this paper, three methods are considered for detecting the resultant harmonics: by Bragg scattering of light, non-collinear scattering of a weak sound wave, and by using an alternating electric field for "readout" and "storage." The first method is easiest for detecting electron density harmonics in piezoelectric semiconductors that are transparent to light. As intense sound waves pass through such a specimen, the permittivity is modulated due to modulation of the electron density. Light may be scattered by the ordinary plasma mechanism, or for greatest efficiency, Bragg scattering could be on a frequency close to the absorption edge. A tunable laser can be used as the light source. The three proposed mechanisms should be observable on semiconductors with a high piezoelectric constant such as CdS, CdSe, Te, GaAs, InSb, and also on surface acoustic waves in laminar piezoelectric-semiconductor structures. Figure 1, references 9: 7 Russian, 2 Western.
[31-6610]

UDC 621.384.83

# USING HOMOGENEOUS MAGNETIC FIELDS FOR ELECTRON BEAM BUNCHING

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 9, Sep 81 (manuscript received 24 Dec 79, after revision 1 Oct 80) pp 1966-1968

AFANAS'YEV, V. D., VISHNYAKOV, V. A. and RUDYCHEV, V. G., Khar'kov State University imeni A. M. Gor'kiy

[Abstract] An analysis is made of the bunching properties of systems consisting of a resonator with transverse magnetic or longitudinal electric field and a magnet with homogeneous field. It is shown that a buncher consisting of a resonator with transverse magnetic field and a deflecting magnet with uniform field is equivalent to a buncher of klystron type consisting of a resonator with longitudinal electric field and a drift section. Although the system with bunching in a magnetic field does not increase the energy spread in the shaped beam, the particles are scattered with respect to angles and the geometric dimensions of the beam increase due to spherical aberration. The phase characteristics of the system are the same as in the klystron buncher. The buncher with longitudinal electric field and deflecting magnet separates the trajectories of the particles in space depending on the time of entrance to the resonator, and is equivalent to a chopper. The bunching properties of this system improve with increasing initial particle energy. Thus the use of a deflecting magnet in place of a drift section gives a shaper equivalent to a system consisting of a chopper and a klystron buncher. References 7: 4 Russian, 3 Western. [20-6610]

UDC 537.523.5

## DYNAMIC CHARACTERISTICS OF ELECTRIC ARC IN ROTATING MAGNETIC FIELD AND PROBLEMS OF STABILITY OF ARC BURNING

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK: SERIYA TEKHNICHESKIKH NAUK in Russian No 8(338), Issue 2, Jun 81 (manuscript received 28 Jul 80) pp 109-117

YEGOROV, V. M., MOTOVILOV, V. V. and PUT'KO, V. F., Kuybyshev Polytechnical Institute

[Abstract] A dynamic model of an electric arc is constructed under conditions of action of a rotating magnetic field, and analytical criteria are derived for stability of arc burning modes in special cases of practical importance. The equations of motion of the arc are derived for the case where the time of transit of the rotating discharge through the chamber is insufficient for swirling of the gas to occur. Arc motion stability is analyzed with consideration of slipping of the electric discharge relative to the mass flow. An expression is found for the region of asymptotic stability of steady-state discharge motion in the rotating magnetic field. It is shown that an arc moving in a rotating magnetic field along a circular trajectory burns stably when the Kaufmann criterion is met, defined with respect to the static current-voltage curve of the moving arc. When the circular trajectory of the arc is fixed by wall or electrodes, the radius vector of the center of mass of the arc channel leads the magnetic field induction vector by an acute angle. Figures 2, references 12 Russian.
[23-6610]

UDC 537.525

## EFFECT OF NORMAL CATHODE CURRENT DENSITY ON STABILITY OF SEMI-SELF-MAINTAINED GLOW DISCHARGE

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 4, Jul-Aug 81 (manuscript received 3 Nov 80) pp 881-883

BRONIN, S. Ya., GEMBARZHEVSKIY, G. V., KOLOBOV, V. M., SUSHKIN, V. M. and SHABASHOV, V. I., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] Normal current density is experimentally determined in a semi-self-maintained glow discharge as the cathode surface is heated with simultaneous registration of limiting discharge parameters. The cathode was a massive copper cylinder heated by a nichrome heater. Cathode temperature was measured by a thermocouple. Experiments were done with nitrogen and air at cathode temperatures of 60 and 350°C. Analysis of the current-voltage characteristics shows that when the cathode is heated at pressures of 5-7 kPa, the voltage applied to the discharge drops by 70-100 V while the total current is maintained. This voltage

drop can be attributed to an increase in the initial cross section of the stream tube, leading to a reduction in resistance of the runoff zone. The energy input in the diffuse form of discharge as the cathode is heated or helium is blown into the cathode layer shows an increase that can be attributed to a reduction of normal current density. It is anticipated that further increasing the cathode temperature will intensify this effect. Figure 1, references 7 Russian.
[24-6610]

UDC 533.6.011.72

## PROPAGATION OF SHOCK WAVES THROUGH WIDENING CHANNELS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 8, Aug 81 (manuscript received 26 Aug 80) pp 1735-1737

GOLOVIZNIN, V. P., Physico-Technical Institute imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] An experimental and computer-aided numerical study was made of the propagation of shock waves through plane channels and through axisymmetrically widening channels. An experiment in the latter case is difficult to set up, while a numerical solution of the problem is just as easy in both cases. The calculations were made for a nonviscous and thermally nonconducting gas, according to the direct method using the McCormack difference scheme and monotonized by nonlinear conservative smoothing. The results of calculations are found to agree satisfactorily with the interferograms obtained for a flat nozzle and for an expanding nozzle, although interaction with the boundary layer could not be completely eliminated in the processing of experimental data. The author thanks A. I. Zhmakin, N. P. Mende and A. A. Fursenko for the helpful discussions, also I. M. Ponomareva for the assistance in formulating the study. Figures 3, references 3 Russian.
[17-2415]

UDC 533.601.312 and 533.601.314

## AERODYNAMIC FORCES ON ROUGH ROTATING CYLINDER IN TRANSVERSE FLOW

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK: SÉRIYA TEKHNICHESKIKH NAUK in Russian No 8(338), Issue 2, Jun 81 (manuscript received 2 Oct 79) pp 32-39

BYCHKOV, N. M. and KOVALENKO, V. M., Institute of Theoretical and Applied Mechanics, Siberian Department, USSR Academy of Sciences, Novosibirsk

[Abstract] An experimental study is done on aerodynamic forces on a rough cylinder in a crossflow in the T-324 low-turbulence wind tunnel at the Institute

of Theoretical and Applied Mechanics, Siberian Department, USSR Academy of Sciences. Airflow was varied from 10 to 60 m/s, degree of turbulence was 0.04 or 0.7%, and the rate of rotation of the cylinder ranged from 0 to 1600 rpm. Measurements were made on a smooth cylinder 150 mm in diameter, and on a rough version produced by cementing sandpaper to the surface with dimensions of the principal fraction being h = 100 μm, so that relative roughness was $h/d = 6.7 \cdot 10^{-4}$. Lift and drag were measured by strain gages with continuous oscillographic recording. It was found that the magnitude and behavior of aerodynamic forces of a rotating rough cylinder differ considerably from the case of a smooth cylinder due to peculiarities of flow in the wall region and the position of points of boundary layer separation. An increase in the degree of flow turbulence has no appreciable effect on aerodynamic forces of a rough cylinder in the transcritical region of Reynolds numbers. Figures 9, references 5: 3 Russian, 2 Western.
[23-6610]

UDC 532.516

MOTION OF VISCOUS FLUID ALONG TRAVELING WAVE AT HIGH SUBCRITICAL REYNOLDS NUMBERS

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK: SERIYA TEKHNICHESKIKH NAUK in Russian No 8(338), Issue 2, Jun 81
(manuscript received 12 Mar 80) pp 52-59

FERDIGALOV, L. Yu., Institute of Cybernetics, UkSSR Academy of Sciences, Kiev

[Abstract] It is shown that hydrodynamic drag reduction is possible in flow of a viscous liquid along on oscillating boundary when the oscillations are matched to a special type of flow that arises in the vicinity of the boundary at high subcritical Reynolds numbers. Flow of a viscous fluid is considered in an infinite flat channel bounded from above by a moving flat wall, and from below by a boundary that is impermeable to the fluid and that oscillates as a transverse traveling wave with time-invariant amplitude and shape. It is assumed that motion of the fluid in the channel with periodic boundary conditi( s is periodic and quasisteady. Analysis shows that active longitudinal-transverse oscillations of the boundary are required to maintain uniform eddy flow in the wall layer. Comparison of viscous flow over a flat plate and uniform eddy flow along a traveling wave shows that energy losses are considerably lower at high subcritical Reynolds numbers in the case of flow along a traveling wave. Figures 3, references 3 Russian.
[23-6610]

UDC 534.231.1

# FREQUENCY CHARACTERISTICS OF NORMAL WAVES IN SHALLOW SEA WITH LAMINAR ABSORBING BOTTOM

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 27, No 5, Sep-Oct 81
(manuscript received 7 Jul 80) pp 669-677

AGEYEVA, N. S. and KRUPIN, V. D., Acoustics Institute imeni N. N. Andreyev, USSR Academy of Sciences

[Abstract] An investigation is made of various frequency-response characteristics of the sound field of a point harmonic radiator in a shallow sea with laminar bottom by a computer method based on normal wave theory. This paper is a continuation of research started in a previous article [N. S. Ageyeva, V. D. Krupin, "Bottom Influence on Sound Field Formation in Shallow Sea", AKUSTICHESKIY ZHURNAL, Vol 26, No 2, 1980, pp 161-166] to explain the interference structure of experimentally observed sound fields in the sea. The sea is treated as a plane-parallel layer with speed of sound that varies with depth. The bottom is modeled by a homogeneous absorbing layer of liquid lying on a homogeneous liquid half-space. Based on this model, a computer program for characteristics of normal waves of a stratified sea with laminar absorbing bottom was used for numerical analysis of the frequency characteristics of modes: phase velocities, attenuation factors, depth distributions of amplitudes, and also horizontal and vertical profiles of the sound field over a wide frequency band. It is shown that despite incomplete information on the acoustic properties of the bottom, a numerical study of the behavior of mode characteristics in the frequency region can reveal some patterns that can serve as guidelines in analyzing the results of observations of the fine interference structure of the sound field in the actual sea, as well as finding practical application in the problem of mode identification. Figures 9, references 8: 7 Russian, 1 Western.
[30-6610]

UDC 535.36:538.3

## DYNAMIC COMPENSATION OF OPTICAL INHOMOGENEITIES IN IODINE LASER

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 8, Aug 81 (manuscript received 19 Sep 80) pp 1764-1765

DOLGOPOLOV, Yu. V., KORMER, S. B., KULIKOV, S. M., MURUGOV, V. M., PEVNYY, S. N., RYADOV, A. V. and SUKHAREV, S. A.

[Abstract] An experimental study was made to determine the feasibility of using inversion of the wave front for compensation of optical inhomogeneities in the active medium of lasers such as a $C_3F_7I$-laser used for thermonuclear fusion. A laser with an unstable telescopic resonator cavity served as the master laser for generating a reference radiation beam with a high degree of space coherence and a small divergence. During focusing of the radiation on a specimen of compressed (under 30 atm) $SF_6$, stimulated Mandel'shtam-Brillouin scattering with a Stokes frequency shift was made to occur under conditions designed to eliminate its effect on the master laser. The results demonstrate the effectiveness of dynamic compensation of optical inhomogeneities in iodine lasers by means of a Mandel'shtam-Brillouin mirror. Figures 2, references 11 Russian.
[17-2415]

UDC 621.378.325

## EFFECT OF STIMULATED RAMAN SCATTERING ON EMISSION CHARACTERISTICS OF SOLID-STATE RING LASER

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 8, Aug 81 (manuscript received 15 Aug 80) pp 1741-1742

KORNIYENKO, L. S., KRAVTSOV, N. V. and NAUMKIN, N. I., Moscow State University imeni M. V. Lomonosov, Scientific Research Institute of Nuclear Physics

[Abstract] An experimental study was made to determine the feasibility of reducing the competitive interaction of opposing waves or compensating the

effect of asymmetric feedback in a solid-state ring laser by means of stimulated Raman scattering inside the resonator cavity. Into the focal region of the resonator cavity of a ruby pulse laser operating in the free-emission mode was inserted a telescopic system with a Raman active medium (benzene, or gaseous hydrogen under a pressure of 40 atm) inside an auxiliary resonator cavity coaxial with the main one. The results indicate that intracavity stimulation of Raman radiation is an effective method of compensation. Figure 1, references 2: 1 Russian, 1 Western.
[17-2415]

UDC 631.375

DETERMINING GAIN OF MOLECULAR LASERS FROM CHARACTERISTICS OF NONCOHERENT INFRARED RADIATION

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 8, Aug 81 (manuscript received 19 Jul 80) pp 1714-1716

KUDRYAVTSEV, N. N. and NOVIKOV, S. S., Institute of Chemical Physics, USSR Academy of Sciences, Moscow

[Abstract] A method of determining the gain of $CO_2$-lasers is shown which utilizes the dependence of the radiation intensities in two vibrational-rotational bands 4.3 and 2.7 μm on two vibrational temperatures: upper-level 001 temperature $T_u = T_3$ characterizing the distribution within the asymmetric mode, lower-level 100 temperature $T_l = T_2$ characterizing the distribution within the symmetric mode and the deformation mode. With sufficient experimental data, the corresponding system of two integrals can be evaluated numerically by the Newton method on a high-speed computer. The calculated temperatures yield the gain according to a well known relation between them. The method was tested on a gas-dynamic ($0.1CO_2 + 0.4N_2 + 0.5He$) pulse laser and checked against the conventional probing transillumination method, the agreement of results having been found to be quite satisfactory. Figure 1, table 1, references 4 Russian.
[17-2415]

UDC 538.561

EMISSION OF COHERENT RADIATION BY BEAM OF RELATIVISTIC ELECTRONS IN UNDULATOR

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 8, Aug 81 (manuscript received 9 Jul 80) pp 1633-1642

KONDRATENKO, A. M. and SAL'DIN, Ye. L., Institute of Nuclear Physics, Siberian Department, USSR Academy of Sciences, Novosibirsk

[Abstract] Emission of coherent radiation by an electron beam moving through a helical undulator, in a laser device without a resonator cavity, is analyzed on

the basis of the results of an earlier study and new approaches. First is considered self-modulation of narrow and wide relativistic beams in the single-transit mode, with constraints on the energy spread and the angular spread of particles as well as on the gradient of longitudinal velocity in the undulator entrance section, these constraints determining the maximum attainable current and radiation energy. Next is considered independent control of the "mass of longitudinal motion" (relating the change in longitudinal velocity to the change in energy, and of the amplitude of the transverse velocity by means of a sufficiently strong extra magnetic field in the undulator. The principle of controlled self-modulation is applicable to the design of a source of coherent submillimeter-wave radiation, a practical powerful source of such radiation not yet being available. Theoretical calculations based on typical numerical data indicate the feasibility of generating an average radiation power of 15 kW with a 200 kW electron source and with 30 cm long bunches appearing at a repetition rate of $10^6$ $s^{-1}$, the controlling magnetic field being 28 kG strong. The authors thank Ya. S. Derbenev for the helpful stimulating discussions and A. N. Skrinskiy for the interest in this study. References 7: 3 Russian, 4 Western.
[17-2415]

UDC 621.373:535

## USING MAGNETIC FIELD TO CONTROL POSITION AND WIDTH OF UNIDIRECTIONAL EMISSION REGION IN RING GAS LASER

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 51, No 3, Sep 81 (manuscript received 2 Apr 81) pp 385-388

KOS'MINA, M. A., STROKOVSKIY, G. A., TOLCHINSKAYA, T. B., TIUNOV, Ye. A. and FRADKIN, E. Ye.

[Abstract] Previous research on competition of opposed waves in ring lasers on a pure isotope has shown symmetric narrowing of the region of unidirectional emission to zero with an increase in the magnetic field intensity on the active medium regardless of sign. This paper describes an experiment in which a new effect is observed: expansion of the region of unidirectional emission as the magnetic field is increased to cover the entire region of single-mode lasing. The studies were done on a three-mirror ring gas laser on the 0.63 μm line. The cell with active medium had Brewster windows and was placed inside a solenoid. Inhomogeneity of the magnetic field along the axis of the optical cavity did not exceed 0.06%/mm, and along the diameter was no more than 0.02%/mm. The active medium was formed by isotopes $^3He$ and $^{20}Ne$ (enrichment 99.85%) in a ratio of 6:1 at a total pressure of 2.4 mm Hg. The cavity also contained a Faraday nonreciprocal device and a loss calibrator. These components were adjusted by varying the polarization parameters of the optical cavity. Lasing intensity in both directions was measured as a function of the detuning of the emission frequency from the center of the amplification line. The discrepancy with the results of

previous research is explained as follows. When a magnetic field is applied to the cell with active medium, the working levels of the gas atoms are split, resulting in three effects: 1. splitting of the amplification line and separation of the Bennett gaps (linear and nonlinear effect); 2. loss of coherence of magnetic sublevels; 3. Faraday rotation of the plane of polarization. It is suggested that the use of a magnetic field to control the position and width of the region of strong competition could be a basis for new capabilities in nonlinear laser spectroscopy using ring gas lasers. Figures 2, references 4 Russian.
[21-6610]

UDC 621.373:535.01

EMISSION FREQUENCY SPLITTING IN RING LASER WITH RECTANGULAR DIAPHRAGM, PART IV

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 51, No 3, Sep 81
(manuscript received 17 Apr 80) pp 493-500

GLUSHCHENKO, Yu. V., RADINA, T. V. and FRADKIN, E. Ye.

[Abstract] A practical expression is derived for calculating the diffraction independence of frequencies of opposed waves in a single-mode ring laser with rectangular diaphragm. It is shown that there is a considerable difference between this expression and the frequency-difference formula derived by the method of perturbation theory. The results of numerical calculations are analyzed and compared with data in the literature. The derivation based on Slater's approach compares favorably with results of numerical integration of Fox and Lee equations with subsequent reconstruction of the field in the cavity using the Kirchhoff integral. Better agreement is observed with lessening diffraction. Thus, Slater's method is applicable to calculation of diffraction frequency splitting in the region of weak diffraction where calculations by numerical methods are difficult. It is found that cavities with degenerate frequency spectrum and minimum diffraction losses of the fundamental mode are characterized by minimum diffraction splitting of frequences. Figures 6, references 16: 15 Russian, 1 Western.
[21-6610]

UDC 621.373:535

SPATIAL FILTRATION OF APODIZED LASER BEAMS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 51, No 3, Sep 81
(manuscript received 2 Apr 80) pp 509-514

KUZ'MINA, N. V., ROZANOV, N. N. and SMIRNOV, V. A.

[Abstract] Small-scale self-focusing in laser facilities is suppressed by a spatial filter made up of two lenses with a diaphragm in their common focal plane to cut off emission perturbations arising in components of the amplification system preceding the filter. In systems with considerable nonlinearity, large-scale "external" self-focusing also becomes important, causing shielding of part of the main beam on the filter diaphragm. The resultant distortions increase with a reduction in the diameter of the diaphragm, complicating the job of selecting filter parameters. While the influence of "external" self-focusing can be analyzed in the "aberrationless" approximation, such calculations lose force near the focal plane. In this paper a numerical and analytical study is done on the passage of laser beams with different degrees of apodization through an amplification stage containing a spatial filter. An approximate analytical expression is found for the field amplitude on the sides of the beam with arbitrary degrees of apodization. An analysis is made of the influence of apodization on distortions introduced by the diaphragm, and the development of these distortions in following nonlinear components. It is shown that the capabilities of spatial filtration of apodized laser beams are appreciably dependent on the shape of the beam and the integral of decay of the system. Figures 6, references 13: 9 Russian, 4 Western.
[21-6610]

UDC 621.378.325

REFINEMENT OF VIBRATIONAL TEMPERATURE MODEL FOR DESCRIBING EMISSION CHARACTERISTICS OF SHORT-PULSE $CO_2$-$N_2$-He LASER

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 9, Sep 81
(manuscript received 22 Jul 80, after revision 4 May 81) pp 1876-1884

PIVOVAR, V. A.

[Abstract] The vibrational-temperature approximation is improved for $CO_2$-$N_2$-He lasers with emission pulse duration of the order of one microsecond or less at high pumping levels $Q/P = 0.5\text{-}1.0$ J/cm$^3$·atm by including effects of non-Boltzmannian population of vibrational levels of nitrogen in times of the order of one microsecond or less, and the influence of anharmonicity in $CO_2$ and $N_2$ oscillators at high pumping levels. Consideration of these effects gives a more exact description of the emission process in the initial period. Kinetic equations including v-v and v-t exchange in the anharmonic approximation are used

to calculate the kinetics of population of vibrational levels of $N_2$ oscillators and the antisymmetric type of vibration of $CO_2$. It is shown that inconsistencies of the vibrational temperature model with respect to time of lasing onset and the amplitude of the first lasing spike can be explained by accounting for non-Boltzmannian population of the first eight electron-excited vibrational levels and anharmonicity of exchange in oscillators of mode $\nu_3$ in $CO_2$ and $\nu_4$ in $N_2$ at short times and high pumping levels. The proposed model that describes pumping processes on the basis of the exact electron distribution function calculated from Boltzmann's kinetic equation for electrons and characterizes processes of vibrational exchange with consideration of anharmonicity in the above-mentioned oscillators improves agreement with observed lasing behavior: within 20-30% for the amplitude of the first lasing spike, and within 10-15% for the time of lasing onset. Figures 7, references 20: 12 Russian, 8 Western.
[20-6610]

UDC 535:621.375.826

## INFLUENCE OF OXYGEN ON NITROGEN LASER EMISSION

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 4, Jul-Aug 81 (manuscript received 18 Nov 80) pp 873-875

ASINOVSKIY, E. I., VASILYAK, L. M. and TOKUNOV, Yu. M., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] An investigation is made of the effect that oxygen additives have on stimulated emission at $\lambda$ = 337.1 nm in a coaxial nitrogen laser. The gas was excited by negative voltage pulses of 9 ns duration with amplitude of 250 kV, rise and fall times of 2.5 ns. Laser emission was analyzed by an MDR-2 monochromator and HSD 1850 photocell with rise time of 0.1 ns, and S7-10B and S7-15 oscilloscopes (passbands of 1 and 5 GHz respectively). A reduction in peak power and energy of an open-air laser with $\lambda$ = 337.1 nm is observed as compared with a pure nitrogen laser. This is attributed to quenching of the upper lasing level by oxygen molecules with quenching cross sectionoof $(52 \pm 11) \cdot 10^{-16}$ cm$^2$. Figures 2, references 9: 5 Russian, 4 Western.
[24-6610]

UDC 621.375.826

CHARACTERISTICS OF CARBON MONOXIDE GAS-DISCHARGE OVERTONE-LASER: I. STEADY STATE

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 41, No 2, Aug 81 (manuscript received 10 Jun 80) pp 289-294

KONEV, Yu. B., KOCHETOV, I. V., KURNOSOV, A. K., PEVGOV, V. G. and DEM'YANOV, A. V., Institute of High Temperatures, USSR Academy of Sciences, Moscow

[Abstract] CO overtone-lasers with high efficiency in the near infrared range of the spectrum are used for various processes in the chemical industry such as separation of isotopes. An earlier study of the populations of vibrational states has indicated the feasibility of a partial inversion at J—1, v → J, v—k transitions not only when k = 1 but also when $k \geq 2$, with the theoretical gain on the first overtone exceeding 0.1 $m^{-1}$ under experimental conditions. In this study a numerical solution of the system of kinetic equations for the populations of levels, including the Boltzmann equation, yields the distribution of CO molecules over vibrational levels and the spectrum of emission on vibrational-rotational transitions. The first overtone is of practical interest, the beginning of its spectrum shifting from v = 12-14 level at a low temperature (80 K) to v = 20-22 levels at higher temperatures (140-180 K) and its peak shifting correspondingly to v = 24-26 levels. The spectrum of the first overtone is also rather wide, owing to the proximity to the threshold, its long-wave edge corresponding to v = 30-32 levels at all these temperatures. The efficiency of emission has been calculated as a function of the temperature and, at the higher temperatures, as a function of the pumping power. The problem of selective emission is also considered, the efficiency depending on the vibrational transition for the first overtone at which a given line of the spectrum corresponding to the maximum gain with respect to the rotational quantum number is extracted. An efficiency of 28% seems to be attainable at W = 1 $W/cm^3$ and T = 150 K with G = $5 \cdot 10^{-4}$ $cm^{-1}$ when $n_{CO} = 1.8 \cdot 10^{17}$ $cm^{-3}$ and $n_{He} = 1.8 \cdot 10^{18}$ $cm^{-3}$. Figures 4, references 8 Russian.
[213-2415]

UDC 536.621.373

THERMAL CONDITIONS OF THE LIGHT GENERATING SYSTEM OPTICAL ELEMENTS IN SOLID-STATE LASER WITH NATURAL COOLING

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 41, No 2, Aug 81 (manuscript received 13 May 80) pp 295-301

DUL'NEV, G. N. and KHANKOV, S. I., Leningrad Institute of Precision Mechanics and Optics

[Abstract] The temperature distribution in the active cell is the most important factor affecting the design and the performance of a solid-state laser. Here

a practical approximate analytical solution to the problem of determining it is shown, an exact solution being quite cumbersome and requiring the aid of a computer. The light generating optical system of a solid-state laser consists essentially of three elements: two parallel cylinders with heat sources (lamp and active cell) inside a heat emanating cylindrical shell (luminaire). Calculation of their temperatures reduces to integration of a system of three first-order linear ordinary differential equations, if the cylinders are assumed to have a large length-to-diameter ratio, that heat emanation occurs at their lateral surface only and quasi-continuously under conditions of natural cooling while the laser operates in the periodic-pulse mode, and that the heat transfer coefficients as well as the thermo-physical/properties of the materials do not depend on the temperature. This system of equations is solved under two additional assumptions, namely that the luminaire heats up much slower than the lamp and the active cell, and that the thermal flux from the lamp to the active cell is much smaller than that from the lamp to the luminaire. On this basis, for typical length-to-diameter ratios $L/D \geq 10$, the excess temperatures of the three elements are calculated as functions of the average pumping power up to 1000 W in the steady-state mode and as functions of the laser operating time at an average pumping power of 25 W during the transient period, for a YAG:$Nd^{3+}$ laser and an ISP 600 flash lamp. Also calculated are the thermal conductances (W/K) between the three elements and from the luminaire to the ambient medium, as functions of the average pumping power in the steady-state mode. The results are compared with experimental data. Figures 3, references 11 Russian. [213-2415]

UDC 533.6.011:537.533

# ELECTRON-BEAM DIAGNOSIS IN NITROGEN: SECONDARY PROCESSES

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 9, Sep 81 (manuscript received 2 Jul 80, after revision 15 Jan 81) pp 1832-1840

REBROV, A. K., SUKHININ, G. I., SHARAFUTDINOV, R. G., LENGRAND, J. C., Institute of Thermal Physics, Siberian Department, USSR Academy of Sciences, Novosibirsk

[Abstract] Existing models that relate intensities of emission stimulated by an electron beam in a gas to the density of the gas, and to the population of vibrational and rotational levels of molecules, are not adequate for accurate interpretation in electron-beam diagnosis. Based on careful experimental studies and analysis of the literature, the authors investigate excitation of state $B^2\Sigma_u^+$ of the nitrogen ion as the probing electron beam interacts with the gas. A kinetic model is proposed for determining the distribution of secondary electrons, their contribution to stimulation of the first negative system of nitrogen bands, and also their influence on measurements of gas density and populations of rotational levels. It is shown that ionization of nitrogen to state $N_2^+B^2\Sigma_u^+$ occurs with more change in the rotational quantum number for impact by secondary electrons than for ionization by fast primary electrons. The linear Boltzmann's integral equation is used in determining the secondary electron distribution function. It is found that secondary electrons can introduce a considerable error in determination of the populations of upper rotational levels. This error can be reduced by doing measurements through a narrow monochromator slit parallel to the beam to minimize halation of the spectral recording. The contribution of secondary electrons to the observed spectra increases for more equilibrium population distributions. Figures 5, references 19: 4 Russian, 15 Western. [20-6610]

UDC 537.5

# INVESTIGATION OF 'FAST' HEATING OF OXYGEN IN NON-SELF-MAINTAINED DISCHARGE

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 4, Jul-Aug 81 (manuscript received 14 Apr 80) pp 720-728

LONDER, Ya. I., MENAKHIN, L. P. and UL'YANOV, K. N., All-Union Electrical Engineering Institute imeni V. I. Lenin

[Abstract] An experimental study is done on the energy balance of electrons in oxygen in a non-self-maintained pulse discharge at $E/N = (8\text{-}30)\cdot10^{-17}$ V·cm$^2$. The experimental data are analyzed and compared with theory [see R. Sh. Islamov, I. V. Kochetov, V. G. Pevgov, "Analiz protsessov vzaimodeystviya electronov s molekuloy kisloroda" (Analysis of Processes of Interaction of Electrons With an Oxygen Molecule), Preprint FIAN (Lebedev Physics Institute), Moscow, 1977, No 169]. Relaxation of energy invested in an oxygen discharge takes place through two channels with very different characteristic times. Heating of a heavy particle gas in oxygen via the channel with characteristic relaxation time much less than the pulse time is called "fast" heating. The experimental method used to measure fast heating in oxygen is based on determining the heating of gas by the pressure rise in a closed discharge chamber with homogeneous pulse discharge. A strain-gage sensor was used to measure pressure. The technique enabled reliable measurement of a pressure change of about 1 kPa per pulse with time resolution of about 50 μs. The measurements were done in oxygen with impurity content (mostly $N_2$) of no more than 0.8% at pressures of 12.6, 25.3 and 101 kPa and initial temperature of about 20°C. The gas was ionized by an electron beam coupled in through aluminum foil. The relative fraction of ion current as a function of E/N is determined from equations of balance of charged particles. It is shown that it is important to account for the chemical reaction of ozone formation in energy balance of electrons in oxygen. When this reaction is considered, satisfactory agreement is observed between experiment and theory. A possible reason for increased discharge current during a pulse may be increasing electron concentration due to an increase in the rate of unsticking as negative ions collide with metastable molecules of $O_2(a^1\Delta_g)$. Figures 6, references 23: 15 Russian, 8 Western.
[24-6610]

UDC 621.384.6

## ACCELERATION OF ELECTRON BEAM IN ARRAY OF RADIAL LINES EXCITED BY EXTERNAL PULSE GENERATOR

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 8, Aug 81 (manuscript received 19 Aug 80) pp 1750-1752

ZAKUTIN, V. V. and SHENDEROVICH, A. M.

[Abstract] An electron beam was successfully accelerated in an array of twin radial lines, upon excitation of the latter by an external pulse generator. The array included accelerating lines, outside radius R = 9 cm and inside radius r = 3 cm, filled with 60NN ferrite. It also included shorting lines around the ferrite rings. The accelerating lines were excited through 12 coaxial cables by a voltage pulse with a 1-8 ns rise time. The accelerating voltage was measured as a function of the ratio of electron transit time to pulse rise time and as a function of the electron beam current. The results agree closely with calculations. Figures 2, references 7: 4 Russian, 3 Western.
[17-2415]

UDC 537.533

## INTENSE PULSED ELECTRON BEAM GENERATION IN MODERATE-DENSITY GAS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 9, Sep 81 (manuscript received 2 Jul 80, after revision 2 Sep 80) pp 1823-1831

BOKHAN, P. A. and KOLBYCHEV, G. V., Institute of Optics of the Atmosphere, Siberian Department, USSR Academy of Sciences, Tomsk Affiliate

[Abstract] Existing electron guns are incapable of shaping electron beams when the gas density in the accelerating region exceeds about $10^{15}$ $cm^{-3}$. The authors discuss a new technique for beam shaping in denser gas by using the effect of escaping electrons in a dense-gas discharge. Experiments are done to determine the type of discharge in which escaping electrons are most efficiently generated at a gas pressure of more than 100 Pa, and an estimate is made of the maximum

generation capacity of such a discharge. The experimental facility was a hermetically sealed quartz discharge chamber containing plane-parallel electrodes: an interchangeable cathode and a grid-type anode with geometric transparency of about 80%. Opposite the cathode and behind the anode was a movable collector grounded like the anode through a low-inductance ohmic current-measuring shunt. The discharge chamber was filled with gas to the required pressure. The chamber was sheathed on the outside with a grounded copper bus having windows for observing the discharge, which was excited by a capacitor charged to 4-10 kV connected to the chamber electrodes through a TGI1-1000/25 thyratron. Signals from the current-measuring shunts in the anode and collector circuit, and from an ohmic voltage divider on the cathode were recorded by a stroboscopic oscilloscope and a chart recorder. A strongly inhomogeneous field was produced by using cathodes consisting of coaxial molybdenum foil cylinders with the ends facing the anode and filled flush with epoxy resin. Massive cathodes made of brass, duralumin, stainless steel or $LaB_6$ were used. The best emission properties were observed in a weak-current volumetric discharge of nanosecond duration, in which practical transfer of the charge accumulated in the discharge capacitor to the electron-beam charge may reach 60-80%. The proposed technique produced an electron beam with energy of 2-3 keV, current density of 10-80 $A/cm^2$, pulse duration of 25-130 ns at a practical efficiency of 30-50% and recurrence rates up to 1 kHz. This method of producing high-intensity pulsed electron beams should be applicable to stimulation of emission in gas lasers. Figures 6, references 14: 13 Russian, 1 Western.
[20-6610]

UDC 538.561

SPONTANEOUS SHORTWAVE EMISSION BY INTENSE ELECTRON BEAM

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 9, Sep 81 (manuscript received 5 Sep 80) pp 1870-1875

LEBEDEV, A. N. and MARTIROSYAN, G. V., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] An investigation is made of spontaneous lengthwise intense magneto-bremsstrahlung of high-current relativistic electron beams with a strong magnetic motion of an individual particle under the action of collective fields is ordered and periodic, and therefore the interference of radiation from different sections of the trajectory leads to narrow-band emission for a wave vector directed along the beam. A high-resolution spectral line of spontaneous radiation that depends on particle energy would indicate the possibility of a laser mechanism of amplification (or stimulated emission) without using external fields. The authors calculate the angular and spectral distribution of spontaneous undulator radiation of a relativistic electron beam with self-field for a specific model in which the particle velocity and emission are directed sharply forward. Effects of induced emission are disregarded, and it is assumed that the radiation frequency is much higher than the Langmuir frequency of the beam electrons so that collective

vibrational properties can be disregarded, and the beam can be considered transparent, i.e. the wavelength is taken as much shorter than the depth of the collisionless skin layer. It is shown that radiation is considerably dependent on beam current: with increasing current the directionality of the radiation deteriorates, total power increases, and the spectrum becomes broader. Figures 3, references 6: 3 Russian, 3 Western.
[20-6610]

UDC 537.533

FILAMENTARY STRUCTURE OF TUBULAR RELATIVISTIC ELECTRON BEAM

Moscow FIZIKA PLAZMY in Russian Vol 7, No 4, Jul-Aug 81
(manuscript received 28 Aug 80) pp 784-789

IVANOV, V. S., KREMENTSOV, S. I., RAYZER, M. D., RUKHADZE, A. A. and FEDOTOV, A. V., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Previous research has revealed azimuthal perturbations of an intense relativistic electron beam as it is transported through a cylindrical waveguide either without beam neutralization or with partial neutralization of the charge by ionization from a neutral gas beam. An analogous effect has been observed when a cylindrical electron beam propagates in a cylindrical waveguide with variable cross section, where the azimuthal perturbations strongly distort the beam structure at considerable distances from the point of injection, the hollow beam being replaced by a continuous structure at a certain distance from the injection point. This paper describes experiments on studying the beam structure with transport in a regular cylindrical waveguide as a function of the length of transport and longitudinal magnetic field intensity. The injector was a Terek-1 accelerator in which the electron flux was produced by a coaxial diode with magnetic insulation. Maximum electron energy was 670 keV, beam current 5 kA, pulse duration 20 ns, residual pressure in the waveguide $5 \cdot 10^{-6}$ mm Hg. Beam macrostructure was studied by self-prints on celluloid plates 0.5 mm thick. It was found that an initially uniform tubular electron beam in the drift space at a certain distance from the plane of injection is broken up into separate jets and takes on an azimuthally inhomogeneous structure. The observed effects are interpreted as development of diocotron instability in a tubular electron beam at finite external longitudinal magnetic field intensities. It is concluded that the diocotron effect must be taken into consideration when designing electromagnetic readiation oscillators based on intense electron beams. Figures 5, references 8: 6 Russian, 2 Western.
[19-6610]

UDC 533.951.8

## TRAPPED ALPHA-PARTICLE MAGNETOACOUSTIC INSTABILITY IN TOKAMAK WITH ELLIPTICAL CROSS SECTION

Moscow FIZIKA PLAZMY in Russian Vol 7, No 4, Jul-Aug 81
(manuscript received 23 May 80, after revision 18 Oct 80) pp 820-827

KALADZE, T. D., Institute of Applied Mathematics, Tbilisi State University

[Abstract] Previous research has shown cyclotron excitation of fast magnetoacoustic waves by trapped alpha-particles formed during nuclear fusion in a tokamak with elliptical cross section. However, previous analysis has ignored longitudinal oscillations of the trapped particles between the magnetic mirrors of the torus, which should be taken into consideration under tokamak reactor conditions. In this paper, refinements are introduced into expressions for increments by accounting for bounce resonances that arise during longitudinal oscillations of trapped particles. General expressions are derived for the increments of buildup of oscillations in cases of weak and strong ellipticity. Analysis of excitation of waves with frequencies close to cyclotron harmonics of strongly trapped alpha-particles shows that bounce resonances may cause additional intensification of the increment of excitation of fast magnetoacoustic waves. Figures 2, references 5: 2 Russian, 3 Western.
[19-6610]

UDC 533.951.8

## BRILLOUIN ELECTRON FLOW INSTABILITY

Moscow FIZIKA PLAZMY in Russian Vol 7, No 4, Jul-Aug 81
(manuscript received 30 Jun 80, after revision 3 Nov 80) pp 930-937

GORDEYEV, A. V., GULIN, A. V. and SAVENKOVA, N. P., Institute of Applied Mathematics imeni M. V. Keldysh

[Abstract] An investigation is made of stability of steady-state Brillouin electron flow with respect to small perturbations that are independent of coordinate lengthwise of the flow velocity. The analysis is distinguished from previous research by the aperiodic nature of development of perturbations as a result of uniformity of perturbations along the direction of flow. It is shown that Brillouin flow of electrons in a cylindrical coaxial vacuum line is unstable with respect to troughs formed on the surface of the electron layer and extending in the direction of the z-axis. The increment of this instability is of the order of $10^9$ $s^{-1}$. Figures 2, references 19: 12 Russian, 7 Western.
[19-6610]

UDC 533.951.8

## NONLINEAR ENERGY PRINCIPLE AND KINK INSTABILITY OF COMPACT TORUS

Moscow FIZIKA PLAZMY in Russian Vol 7, No 4, Jul-Aug 81
(manuscript received 29 Aug 80) pp 938-942

DREYZIN, Yu. A. and SOKOLOV, Ye. P., Moscow Physicotechnical Institute

[Abstract] MHD stability of a compact torus configuration is studied by using a nonlinear variational principle. The unstable mode is found for the entire class of configurations in which the plasmoid is enclosed in a long cylindrical chamber, and one of the possible versions of development of this instability is studied under nonlinear conditions. An analysis is made of two possible methods of stabilizing such an instability by magnetic mirrors and an azimuthal magnetic field. It is shown that a long plasmoid can be made stable by a relatively weak toroidal magnetic field. It is pointed out that the MHD approximation used in this work must be refined for more complete analysis of the stabilization problem with consideration of the finiteness of the Larmor radius of ions and other kinetic effects. Figures 2, references 9: 4 Russian, 5 Western.
[19-6610]

UDC 517.958

## OPTIMIZING SYSTEMS FOR AFTER-ACCELERATION OF INTENSE CHARGED PARTICLE FLUXES

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian
Vol 21, No 5, Sep-Oct 81 (manuscript received 6 Jan 81) pp 1333-1338

KULYGIN, V. M., SVESHNIKOV, A. G., SEMASHKO, N. N. and YAKUNIN, S. A.,
Moscow

[Abstract] In some design problems, such as negative-ion injectors for controlled fusion reactors and ion engines for spacecraft, it is necessary to provide additional acceleration of streams of particles pre-shaped into an intense beam. In this situation, the parameters of the after-acceleration system such as geometric dimensions and distribution of potentials on the electrodes must be selected from compromise considerations. On the one hand, the secondary particles should pick up minimum energy on the path from the point of production to the wall to avoid destruction, and on the other hand, the divergence of the ion beam and deviation from the axis of the system must be minimized. The authors consider this optimization problem and propose an algorithm for solution that is applicable to the design of after-acceleration systems. The parameters of the criterion functional are the geometric dimensions of the region and the distribution of electric potential at the boundary. The solution minimizes the angle of divergence at the output and the energy losses on acceleration of secondary-ionization particles and electrons. The efficacy of the proposed technique is demonstrated by a specific example. Figures 2, references 10 Russian.
[37-6610]

UDC 535.317.1

## STATIC AND DYNAMIC THREE-DIMENSIONAL HOLOGRAMS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 8, Aug 81
(manuscript received 23 Jun 80) pp 1648-1655

DENISYUK, Yu. N.

[Abstract] The modal theory of three-dimensional holograms, proposed in 1976 by the Soviet physicist V. G. Sidorovich, is here applied to an analysis of the image producing characteristics of brightness waves and their dependence on the properties of the light-sensitive medium. On a volume of such a medium is assumed to impinge a complex wave consisting of superposed plane waves which, as a result of interference, produce an intricate brightness pattern. The hologram is recorded in a medium with a phase response. The interaction of the medium with light, including the generation of acoustic waves and a phonon echo, is interpreted in terms of this theory. Owing to this interaction, dynamic holograms recorded in resonant scattering media make it possible to invert wave fronts and to record not only space characteristics but also time characteristics of wave fronts. Static holograms feature a high diffraction efficiency and make it possible, with a sensitized reaction of the photo-oxide, to modulate the refractive index in the visible range through absorption of near-ultraviolet radiation. Figures 4, references 26: 17 Russian, 9 Western.
[17-2415]

UDC 535.33

## SUPERLUMINESCENCE SPECTRAL BEHAVIOR

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 51, No 3, Sep 81
(manuscript received 21 Apr 80) pp 406-410

MALIKOV, R. F., MALYSHEV, V. A. and TRIFONOV, Ye. D.

[Abstract] An analysis is made of the way that pulse shape and spectral behavior depend on homogeneous and inhomogeneous broadening in collective

spontaneous emission of a polyatomic inverted system under conditions where relaxation of the nondiagonal elements of the density matrix and the associated dipole moments of atoms occurs more slowly than the de-excitation process. A distinguishing feature of this superluminescence effect is square-law dependence of intensity on inversion density. The analysis is based on a system of contracted equations of semiclassical superluminescence theory, describing the behavior of slowly changing amplitudes of waves of the electric field and polarization of the electronic subsystem propagating in one direction. Solution of this system of equations gives the pulse shape of cooperative spontaneous radiation and the Fourier spectrum of emission at different values of the homogeneous and inhomogeneous times of transverse relaxation. It is shown that the superluminescence spectrum is symmetric relative to the transition frequency in an isolated atom. As phase relaxation increases, the number of peaks in the emission pulse and in its spectrum decreases. Calculation shows that Stark splitting correlates with splitting of the corresponding doublets in the emission spectrum. It is shown that the observed spectral shape is due to optical nutation in the proper field of superluminescent emission. Since spectral shape is found to be weakly dependent on pulse delay time, the observed structure can be taken as an indicator of superluminescence, especially in cases where the oscillatory structure of the de-excitation pulse is unresolved due to superposition of pulses with different delay times. Figures 3, references 12: 5 Russian, 7 Western. [21-6610]

UDC 535.87:621.373:535

## LASER MIRRORS FOR FAR XUV

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 51, No 3, Sep 81 (manuscript received 10 May 79, after revision 24 Feb 81) pp 515-519

BOGACHEV, M. B., KOLTYGIN, V. M., PLOTKIN, M. Ye., RAGOZIN, Ye. N. and SUKHODREV, N. K.

[Abstract] Optical cavities for the extreme ultraviolet require mirrors that reflect effectively in the shortwave region with normal incidence. The best reflectors in the region of wavelengths shorter than 1000 Å are refractory metals. The authors study mirrors for the XUV region made from massive polycrystal specimens of molybdenum, tungsten and rhenium produced by double remelting in vacuum. The reflectivity was measured by a VMR-2 vacuum monochromator with a helium discharge in a capillary as the source of radiation and a photomultiplier equipped with a converter to shift UV radiation into the visible band. Angle of incidence was 12°. An investigation was also made of the surface roughness of glass, steel and tungsten by the method of interference bands of equal chromatic order. After polishing and before measurements, the surfaces were cleaned with organic solvents. It was found that hexane is best for this purpose. The coefficients of reflection were measured for incident wavelengths from 537 to 1200 Å after prolonged exposure to air. Rhenium showed the highest reflectivity of 34% at 584 Å, while molybdenum had the lowest

reflectivity of 9% at 537 Å. It was found that polished glass can be used as a backing for a mirror with specular reflection down to wavelengths of the order of 100 Å, while polished metal mirrors are capable of specular reflection only down to about 500 Å at normal incidence. Unexpectedly, isolated large roughnesses with dimensions of the order of 500 Å x 200 μm could be distinguished by eye in visual inspection of the surface. Figures 3, references 5: 2 Russian, 3 Russian.

UDC 621.378.325

OPTICAL BISTABILITY AND HYSTERESIS IN FOUR-BEAM WAVEFRONT REVERSAL IN FERROELECTRICS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 9, Sep 81 (manuscript received 16 Sep 80) pp 1990-1993

KUKHTAREV, N. V. and SEMENETS, T. I., Institute of Physics, UkSSR Academy of Sciences, Kiev

[Abstract] Theoretical studies of the four-beam wavefront reversal technique have demonstrated that bistable states show up in liquids for light beam intensities of about $10^4$ W/cm$^2$. This effect could be used to develop new non-resonator optical devices such as optical transistors and memory units. In this paper it is proposed that optical bistability should be possible with wavefront reversal in ferroelectrics where the effect takes place at low intensities of the order of 0.1 W/cm$^2$, enabling the use of cw lasers in systems with bistable components. An analysis is made of equations for holographic wavefront reversal at high efficiencies, where new effects may show up in the system, and conditions are found for experimental realization. It is shown that in the case of high wavefront reversal efficiencees in ferroelectrics, optical bistability and hysteresis may arise due to discontinuities of the isophase surfaces of the holographic gratings. These effects may be realized in $LiNbO_3$ and $LiTaO_3$ at intensities of the order of 0.1 W/cm$^2$. The parameters of bistability can be controlled by an external electric field of about 30 kV/cm. References 10: 5 Russian, 5 Western.
[20-6610]

SUPPRESSING EFFECT OF SMALL-SCALE SELF-FOCUSING WITH BEAM ROTATION, JITTER OR WOBBLE

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 9, Sep 81
(manuscript received 24 Sep 80, after revision 13 Jun 81) pp 1996-1999

ASKAR'YAN, G. A. and MUKHAMADZHANOV, M. A., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences, Moscow

[Abstract] Self-stress of intense beams in a medium as a result of arisal of a nonlinear waveguide causes rapid growth of small-scale inhomogeneities of beam intensity distribution leading to breakdown of optical and active media, nonlinear scattering and absorption, and preventing collapse of the beam as a whole. The authors consider new possibilities for eliminating these small-scale effects and their consequences by small beam movements that do not noticeably change beam dimensions: rotation, wobbling, flicker and jitter. An analysis is made of inertial nonlinearities where the risetime of nonlinear refraction is large compared with the period of beam rotation or wobble, so that intensity averaging becomes important for the dynamics of nonlinear refraction, and fast nonlinearities that must be suppressed to avoid beam collapse. Beam motion was produced by a rotating Dove prism or an electrooptical deflector system. Experiments show the feasibility of controlling small-scale processes of nonlinear refractions by slight beam movements. In particular, beam rotation can eliminate small-scale processes while allowing axial collapse of the beam, which is important for producing high concentrations of energy. Figures 5, references 10: 6 Russian, 4 Western.
[20-6610]

UDC 536.21:65.011.56

FAST-ACTION AUTOMATED SYSTEM FOR HIGH-TEMPERATURE MEASUREMENTS (2500-6000 K) WITH HEATING BY LASER EMISSION

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 4, Jul-Aug 81
(manuscript received 12 Dec 80) pp 839-848

SHEYNDLIN, M. A., KIRILLIN, A. V., KHEYFETS, L. M. and KHODAKOV, K. A., Institute of High Temperatures, USSR Academy of Sciences

[Abstract] Considerable experimental data have now been accumulated on the thermophysical properties of carbon at high pressures and temperatures. Nonetheless, certain key problems remain unsolved relating to the phase diagram of carbon. Of particular interest among these problems is the temperature level at the solid-liquid-vapor triple point. In this connection the authors describe a system of measuring the temperature of specimens heated by high-intensity steady-state laser radiation in a chamber under high inert gas pressure. The system includes a monochromatic pyrometer, a fast-acting spectral ratio micropyrometer with large linear dynamic range ($10^5$), equipment for

high-speed registration of emission spectra, and a system for controlling the experiment and computer-processing the results. A schematic of the experimental facility is given, as well as flowcharts of the programs for spectral measurements and data processing. Results are compared with data in the literature. Figures 6, references 7: 2 Russian, 5 Western.
[24-6610]

UDC 535.317.1

# NEW EXPERIMENTAL RESULTS ON EFFECTIVE USE OF RANDOM-PHASE MASK IN HOLOGRAPHIC MEMORIES

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 51, No 3, Sep 81
(manuscript received 27 Mar 80) pp 535-541

AKAYEV, A. and KERIMKULOV, T.

[Abstract] Previous research has shown that the use of a random-phase mask for coding the input page provides an effective means of producing high-quality holographic backing stores. The theory of recording of Fourier holograms for a digital store of this kind based on Rayleigh law of Fourier transform distribution has been effectively used for analyzing results of experiments. However, the question of the validity of the assumption of Rayleigh distribution remains open. Furthermore, experiments have shown that four-level random-phase masks are no more effective than two-level masks, although theory predicts that they should be twice as effective. Another problem that has not been studied is the influence that the information content of the input page has on the dynamic range of its Fourier transform. This paper gives the results of computer experiments by the method of statistical modeling that were designed to answer these questions. The results confirm the validity of Rayleigh law for amplitude distribution of Fourier transforms. It is also demonstrated that the two-level random-phase mask is optimum rather than the four-level mask. A special method is proposed and experimentally verified for forming the input page with relatively high stability of the dynamic range of amplitude of the Fourier transform of the page regardless of content. Figures 4, references 7: 4 Russian, 3 Western.
[21-6610]

UDC 535.317.1

## RECONSTRUCTING COMPLEX FIELD AMPLITUDE OF OBJECT OBSERVED THROUGH OPTICALLY INHOMOGENEOUS RANDOM MEDIUM

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 51, No 3, Sep 81
(manuscript received 10 Nov 80) pp 561-563

SVIRIDOV, K. N. and SIDEL'NIKOV, V. N.

[Abstract] Previous research has come up with various approaches to the problem of reconstructing the complex amplitude of the field of an object that has arisen because of difficulties in directly recording the phase of a received light pulse (the "phase" problem of partial coherence theory). Most promising is an iteration procedure based on sequential processing of two distributions of light pulse intensity recorded simultaneously in two different reception planes. When an optically inhomogeneous random medium is situated between the observed object and the telescope aperture, the complex amplitude reconstructed by this approach is randomly distorted. The authors suggest a possible method of compensating these distortions and isolating the complex amplitude of the field of the object. The approach is based on separate statistical averaging of the amplitude and phase of the reconstructed complex amplitude for several independent realizations. To do this, several pairs of distributions of field intensity are recorded during observation in two planes with exposure time equal to or less than the interval of time correlation of fluctuations of the optically inhomogeneous medium. Reconstruction allows the object to be "seen" through optically inhomogeneous random media. References 6: 3 Russian, 3 Western. [21-6610]

UDC 537.533.331

## BOX-LIKE ELECTROSTATIC LENS WITH FOUR PLANES OF SYMMETRY

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 9, Sep 81
(manuscript received 22 Jul 80) pp 1804-1808

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[Abstract] A study is done on the optoelectronic properties of two-electrode box-like electrostatic lenses with four planes of symmetry. Each electrode is made up of four plates held at the same potential, and the potentials of the two electrodes are different in the general case. It is assumed in the calculations that the gap separating the two electrodes is infinitesimally small, and that the length of the generatrix of the plates is infinitely long. Lenses are considered in which the line on each of the sides of the box separating plates of different potentials is a straight line segment, and a semicircle. The field for such an electrostatic system is found by solving the Dirichlet problem

with zero boundary conditions for the potential on three sides of an infinitely long box of rectngular cross section, and non-zero conditions on the fourth side of this box. Analysis of optoelectronic properties is based on the theory of lenses with two planes of symmetry, assuming that the potential is equal to zero wherever particle velocity is equal to zero. Cardinal elements and coefficients of spherical aberration are given at values of linear magnification equal to -1, 0 and $\infty$. The ratio of potentials on the electrodes $\Phi = \Phi_2/\Phi_1$ was varied so that the quantity $\sqrt{\Phi}$ for accelerating lenses and the quantity $1/\sqrt{\Phi}$ for decelerating lenses took on values in the interval [1.2, 10]. The results of the analysis show that lenses of this type can be used in ottoelectronic systems to produce a correct image of an object with improved focusing in one direction and partial elimination of third-order spherical aberration. They can also be used as correctors of spherical aberration in both directions in optoelectronic systems that contain astigmatic elements. Figures 2, references 3: 1 Russian, 2 Western. [20-6610]

UDC 535.317.25

RESOLUTION OF POLARIZATION-TYPE ELECTRO-OPTICAL DEFLECTOR

Minsk IZVESTIYA AKADEMII NAUK BSSR: SERIYA FIZIKO-MATEMATICHESKIKH NAUK in Russian No 4, Jul-Aug 81 (manuscript received 30 Jan 81) pp 79-82

PILIPOVICH, V. A., POLYAKOV, V. I. and KONOYKO, A. I., Institute of Electronics, BSSR Academy of Sciences

[Abstract] An analysis is made of the resolution of a light-deflecting system that is made up of an electro-optical deflector of polarization type that effects parallel displacement of a convergent light beam, and the optical system that produces the light beam. Assuming that all optical elements have a high degree of optical homogeneity, the resolution of the light-deflecting system is determined by diffraction broadening of the light beam and the sum of all aberrations of the illuminating and deflecting systems. The electro-optical deflector is made up of electro-optical polarization selectors and birefringent elements with optical components that are plane-parallel plates. Since the birefringent component in the general case splits a monochromatic light beam into ordinary and extraordinary waves with different indices of refraction, the depth of focusing of deflected light beams is different. Expressions are given for resultant defocusing, transverse and longitudinal positional chromatism, transverse and longitudinal spherical monochromatic abberations. Analysis of these relations shows that spherical aberration of the electro-optical deflector can be disregarded. It is shown that coma is determined by the parameters of the optics that shape the light beam, and that the deflecting system should not introduce astigmatism. Complete aberrational analysis demonstrates that the optical system of the electro-optical deflector has almost no effect on resolution, and that the major contribution to deterioration of resolution is from diffraction broadening of the light beam and spherical aberration of the optics that shape the light beam. It is experimentally verified that resolution can be improved by minimizing these factors. Figure 1, references 4 Russian. [18-6610]

PARTICULARS OF ULTRASHORT INTENSE LIGHT PULSE PROPAGATION IN MULTIMODE OPTICAL FIBERS

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian
Vol 34, No 7, 5 Oct 81 (manuscript received 18 Jul 81, after revision 24 Aug 81)
pp 391-395

NESTEROVA, Z. V., ALEKSANDROV, I. V., POLNITSKIY, A. A. and SATTAROV, D. K.

[Abstract] Nonlinear conversion of laser emission in fiber-optics bundles is attained at anomalously low intensity of the light flux at the input to the bundle. This opens up prospects for studying the mechanism of nonlinear conversion of intense radiation over a wide range of exciting pulse energies. In this paper experiments are done to determine the behavior of nonlinear processes arising in fiber-optics bundles with stimulation by ultrashort light pulses. The time characteristics of light pulses are analyzed by the Agat optoelectronic chamber with time resolution of 2-3 ps. The results show that self-stress of intense laser emission in a multimode fiber-optics bundle leads to a change in propagation conditions with possible self-compression of ultrashort light pulses on frequencies of the Stokes components of stimulated Raman scattering. Detailed studies with equipment having sub-picosecond resolution should reveal the fine points of the process of unsteady stimulated Raman conversion of laser emission in fiber-optics bundles. An analysis should be made of the feasibility of using components of stimulated Raman scattering in such systems for data transmission. Figures 3, references 7: 3 Russian, 4 Western.
[34-6610]

UDC 537.525

## EXPLOSIVE MODEL OF ARC-DISCHARGE CATHODE SPOTS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 51, No 9, Sep 81
(manuscript received 21 Apr 80, after revision 22 Sep 80) pp 1809-1811

KRAT'KO, S. A., Scientific Research Institute of Applied Physical Problems at Belorussian State University imeni V. I. Lenin, Minsk

[Abstract] The author proposes a mechanism of explosive vaporization as a basis for unsteady models of cathode spots in an arc discharge. It is assumed that processes of phase explosion of microinhomogeneities are periodically repeated in the cathode spot. A necessary condition for this effect is current density of $10^{10}$-$5 \cdot 10^{11}$ A/cm$^2$. If this condition is met, resistive heating will increase temperature to the critical point beyond boiling within $10^{-5}$-$10^{-7}$ s, after which superheated vapor, liquid and ions will be ejected in $10^{-7}$ s. It is assumed that the energy or resistive heating is expended on phase explosion and can be disregarded in the general energy balance. The proposed model is confirmed by numerical calculations based on a method of existence diagrams. Figure 1, references 12: 7 Russian, 5 Western.
[20-6610]

UDC 533.951

## LONGITUDINAL WAVE AMPLIFICATION IN MODULATED BEAMS: I. FUNDAMENTAL HARMONIC AMPLIFICATION

Moscow FIZIKA PLAZMY in Russian Vol 7, No 4, Jul-Aug 81
(manuscript received 20 Mar 80, after revision 4 Jan 81) pp 764-774

GENDENSHTEYN, L. E. and POLOVIN, R. V., Khar'kov Physicotechnical Institute, UkSSR Academy of Sciences

[Abstract] Previous research on motion of a particle beam through a plasma has shown that premodulation of beam density may result in amplification. In this paper the authors find the band of amplified frequencies and determine the

increments of amplification on the fundamental harmonic for an extensive class of modulations. Passbands for an interrupted beam are found, and an examination is made of jumps in the amplification increment and the effect of "rigid excitation." A subsequent article will deal with combination waves, and it will be proved that the direction of increase in the waves coincides with the direction of propagation, i.e. that amplification occurs rather than non-transmission. The analysis is restricted to waveforms propagating in the direction of beam inhomogeneity, considering the beam and plasma to be infinite and uniform in the other two dimensions. Thus all investigated quantities depend only on time and one coordinate. The linear theory is considered in the case of periodic modulation, the beam and plasma being taken as cold. The following effects are observed: 1. reduction of the increment of amplification as modulation increases for an arbitrary density profile (in the case of partial modulation and large gain); 2. a new passband shows up in the case of a beam of plasmoids of arbitrary shape; 3. jumps in the increment of amplification as a function of frequency; 4. possibility of rigid excitation of oscillations (increment of amplification limited from below). A formula is derived for simple computation of the spectrum and increments of amplification for arbitrary assigned periodic modulation. Figures 3, references 10: 9 Russian, 1 Western.
[19-6610]

HEAT TRANSFER IN TURBULENT LASER PLASMA

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian
Vol 34, No 6, 20 Sep 81 (manuscript received 16 May 81) pp 325-328

BYCHENKOV, V. Yu. and SILIN, V. P., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] It has been realized for some time that the discrepancy between the theory of laminar plasma flows and experimental results can be explained by assuming a transition to the turbulent state due to development of ion-sound instability excited by electronic heat flux with resultant suppression of heat transfer. However, the theoretical investigation of the problem has been hampered by lack of analytical equations showing the relation between the heat flux and temperature gradient in a turbulent laser plasma. In this paper the authors formulate principal equations of turbulent flow of a nonisothermal collisionless plasma. These equations are based on the angular distribution of turbulent fluctuations determined by the authors under conditions where ion-sound turbulence is initiated by intense electronic heat flux. It is shown that for a plasma with developed ion-sound turbulence the thermal conductivity coefficient is inversely proportional to the absolute value of the turbulent heat flux density. This corresponds to a reduction in the effective mean free path of electrons with increasing intensity of turbulent fluctuations. As a consequence of nonlinearity in the relation between heat flux and temperature gradient, there is a considerable reduction in the scale of spatial variation in temperature and other gasdynamic quantities as compared with conventional laminar theory. Estimates show that this scale is of the order of $10^{-4}$ cm or less. References 12: 3 Russian, 9 Western.
[36-6610]

RESONANT INTERACTION OF PLASMA BEAM WITH EXCHANGELESS MAGNETOSTATIC SURFACE WAVE

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 23, No 9, Sep 81
(manuscript received 10 Feb 81) pp 2580-2586

GULYAYEV, Yu. V., ZIL'BERMAN, P. Ye. and RAYEVSKIY, A. O., Institute of Radio Engineering and Electronics, USSR Academy of Sciences, Moscow

[Abstract] The authors investigate resonant interaction of a surface spin wave in a saturated ferromagnetic with a surface plasma wave in a beam passing over the surface of the ferromagnetic. A dispersion equation for the interacting waves is derived and solved in the exchangeless approximation and in the first order with respect to relativistic parameters ($1/c^2$, where c is the speed of light). There are three resonances for a beam with not too high density. Close to two of these resonances the spectra move apart, while close to the third they tend to merge (the waves synchronize each other), and one of the branches may show instability. This is impeded by dissipation processes and by sticking of electrons to the surface of the ferromagnetic. However, under actual conditions amplification may reach 75 dB/cm in the ferromagnetic-plasma beam structure in a relative band of $4 \cdot 10^{-3}$ at a frequency of 3 GHz. The width of the resonance line in the ferromagnetic need not be narrow, and in fact may be 10-100 times wider than that necessary for amplification in structures of the ferrite-semiconductor type. The maximum increment of instability occurs when ferromagnetic plates are used with thickness considerably exceeding a wavelength. Sticking and dissipation may have a considerable effect on the form of spectrum of interacting waves, as well as on the condition of instability. Figures 3, references 13: 11 Russian, 2 Western.
[35-6610]

NONLINEAR SATURATION OF STIMULATED MANDELSTAM-BRILLOUIN SCATTERING IN RAREFIED NONISOTHERMAL PLASMA

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 34, No 7, 5 Oct 81 (manuscript received 6 Aug 81) pp 385-388

SILIN, V. P. and TIKHONCHUK, V. T., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The theory of stimulated Mandelstam-Brillouin scattering as applied to a laser plasma is of interest because of possible resultant limitations of heating efficiency. On the other hand, research has shown that correct calculation of the coefficient of reflection due to induced Mandelstam-Brillouin scattering from rarefied plasma layers requires consideration of nonlinear effects, and in particular the nonlinearity of ion sound for a nonisothermal plasma. Although this kind of nonlinearity was taken into consideration in theoretical studies by Gorbunov et al. [see L. M. Gorbunov, ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI, Vol 65, 2973, p 990;

L. M. Gorbunov, V. I. Domrin, D. K. Salikhov, KRATKIYE SOOBSHCHENIYA PO FIZIKE FIAN, No 9, 1981], there were no changes in the representations of strong scattering. In this paper, the authors show that the process of harmonic generation considered by Gorbunov et al. leads to sharp restriction of stimulated Mandelstam-Brillouin scattering in a rarefied plasma. A system of equations is derived for the electric field amplitudes of the incident and backscattered electromagnetic waves, and the amplitudes of the fundamental and second harmonics of sound waves. An analysis is made of this system in the near-threshold region, assuming that the amplitude of the second harmonic is much smaller than the fnndamental perturbation. The limiting value of the local coefficient of reflection is found, which enables evaluation of the total attenuation of power emission due to stimulated Mandelstam-Brillouin scattering as the emission propagates in a rarefied plasma. It is shown that the reflected flux is a small fraction of the incident energy regardless of the scale of density inhomogeneity. References 12: 7 Russian, 5 Western.
[34-6610]

UDC 533.95

SCIENTIFIC-ENGINEERING APPROACH TO PROBLEM OF MODELING AND ANALYZING PLASMOTRON DYNAMICS AS TECHNOLOGICAL OBJECT: III, ANALYSIS OF DYNAMICS IN CASE OF DISTRIBUTED EXTERNAL FACTORS, METHOD OF DYNAMIC PLASMOTRON OPTIMIZATION

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK: SERIYA TEKHNICHESKIKH NAUK in Russian No 8(338), Issue 2, Jun 81 (manuscript received 12 Feb 81) pp 94-108

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[Abstract] The dynamic characteristics of a plasmotron are analyzed by using the concept of time lags. The radiation of the electric arc is taken into consideration in the analysis as the contribution from this source to the overall energy balance becomes appreciable for plasmotrons of high unit power. The proposed model also contains distributed and lumped-parameter perturbing functions. A method is given for determining lag times of different orders in general form for an industrial plasmotron, and for numerical calculation of these times. Functions of the transient process are analyzed for the individual characteristics of different approximations. It is recommended that the passband determined from lag times of different orders be used to estimate the dynamic properties of the plasmotron on the design stage with and without a control system. Possible amplification of extremum values of lag times of an external factor in the plasmotron could be used to stabilize modes of operation of the device. On this basis, a technique is worked out for dynamic optimization of a plasmotron with chemical reactions. Figures 6, references 35 Russian.
[23-6610]

UDC 537.523.5

## CALCULATING LIMITING ENERGIES OF GAS-DISCHARGE FLASHLAMPS

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK: SERIYA TEKHNICHESKIKH NAUK in Russian No 8(338), Issue 2, Jun 81 (manuscript received 8 Jul 80) pp 134-142

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[Abstract] Previous research on the limiting energy loads of gas-discharge flashlamps shows a rather complex pattern that reflects a variety of factors responsible for the relation between maximum energy and major lamp parameters. In this paper a theory is proposed that enables relatively simple prediction of limiting energies of lamps on the basis of predetermined structural and electrophysical parameters. It is assumed that the input power pulse is square-wave. Based on a comparison of theoretical and experimental data, an analysis is made of the capabilities of the proposed method of prediction, and the reliability of results is evaluated. A investigation is made of the influence that various factors have on the limiting energies of gas-discharge radiation sources. Figures 6, references 22: 21 Russian, 1 Western.
[23-6610]

UDC 533.7

## DEFINITION OF STRONGLY NONIDEAL PLASMA

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 4, Jul-Aug 81 (manuscript received 21 Mar 80) pp 680-685

IOSILEVSKIY, I. L., Moscow

[Abstract] One of the impediments to the investigation of properties of a nonideal plasma is a lack of an exact definition of the concept of a strongly nonideal plasma, since the parameter conventionally used for this purpose contains an arbitrary and ambiguous quantity--the density of free charges. The author discusses situations where ambiguity of the definition of the parameter of nonideality causes difficulties. It is shown that the difficulties involved in using the conventional parameter of nonideality are not eliminated in a rigorous approach based on plasma expansion with respect to degrees of activity. In the region of $Ry/kT \gg 1$, the smallness of the conventional nonideality parameter $\Gamma \equiv e^2/kTr_D$ (where $r_D$ is the Debye radius) does not in itself guarantee accuracy of the traditional Saha ideal-gas approximation. Figures 2, references 12: 9 Russian, 3 Western.
[24-6610]

UDC 533.951

# MODEL OF QUASISTEADY HEAVY INERT GAS BEAM PLASMA: I. GENERAL DESCRIPTION OF MODEL

Moscow TEPLOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 19, No 4, Jul-Aug 81 (manuscript received 30 May 80) pp 709-719

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[Abstract] A model is proposed for a quasisteady plasma of dense inert gases ($N \sim 10^{19} - 10^{21}$ cm$^{-3}$) produced by a homogeneous high-energy electron beam. The model describes a plasma with electron concentration of $n_e \sim 10^{14} - 10^{18}$ cm$^{-3}$ and electron temperature $T_e \sim 0.5$-1 eV throughout the range of practically realizable beam current densities. Consideration is taken of the decisive role of the block of excited states in the kinetics and energetics of the plasma electrons. Both collisional processes (depopulation of excited states of atoms and molecules by electron impact) and radiative processes (photodissociation of excimers) are taken into account. The mechanism of excitation energy conversion is analyzed and simple relations are derived for calculating plasma parameters under conditions of total domination of dissociative recombination when processes of triple recombination and photodissociation are insignificant. The next article will deal with the analogous situation when triple recombination or photodissociation predominates, thus covering the entire region of existence of this type of plasma. The influence of nonequilibrium on temperature conditions is discussed. In the mode of total predominance of dissociative recombination, the electron temperature is determined by inelastic collisions with excited particles, does not depend on external factors, and has a minimum value of about 0.4 eV. This is due to the mechanism of energy domination and settling of concentrations of excited and charged particles. References 18: 10 Russian, 8 Western.
[24-6610]

# EFFECT OF $Ar^+$ AND $O_2^+$ ION INJECTION ON SUPERCONDUCTING PROPERTIES OF NIOBIUM FILMS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 23, No 9, Sep 81
(manuscript received 29 Dec 80, after revision 27 May 81) pp 2858-2860

BELYAVSKIY, Yu. V., VENDIK, O. G., GODAKOV, S. S., KOZYREV, A. B. and SAMOYLOVA, T. B., Leningrad Electrical Engineering Institute imeni V. I. Ul'yanov (Lenin)

[Abstract] Ion implantation is used to study the effect of $Ar^+$ and $O_2^+$ on the superconductor properties of Nb films. Since the mass ratio of these ions is close to unity, it can be assumed that the nature of the resultant structural defects will be the same, so that an evaluation can be made of the influence that such factors as structural defects and chemical activity of the dopant have on the superconducting properties of the films. Ion energy was 70-80 keV, and implantation was done at 300 K and pressure of $10^{-4}$ Pa. Maximum dose was $2 \cdot 10^{16}$ $cm^{-2}$. The electrical characteristics of the superconducting films were measured by a standard four-probe method after each cycle of irradiation. It was found that the critical pinning temperature in a perdendicular magnetic field at 4.2 K decreases monotonically with increased irradiation dose for either type of ion. The film resistance increases monotonically with increasing dose, and the critical temperature drops. The reduction in critical temperature is stronger for $O_2^+$ than for $Ar^+$. The critical magnetic field increases with low doses of $Ar^+$, passes through a maximum with increasing dose, and then begins to fall. $O_2^+$ implantation causes a reduction in the critical magnetic field that falls linearly with increasing dose, except in films with the lowest resistance, which show a weaker maximum than in the case of $Ar^+$. The difference in behavior can be attributed to the greater chemical activity of the $O_2^+$ ions. Figures 2, references 3: 2 Russian, 1 Western.
[35-6610]

UDC 517.958:536.2

# APPROXIMATE SOLUTION OF HEAT CONDUCTION PROBLEM IN PRESENCE OF MOVING HEAT SOURCE

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian
Vol 21, No 5, Sep-Oct 81 (manuscript received 19 Nov 79) pp 1329-1333

OSTROUMOV, A. V., Moscow

[Abstract] In analysis of the thermal dynamics of contact friction the problem arises of determining the temperature field generated by a moving source of heat. In this paper a simple formula is derived for solving this problem. The analysis is based on a model in which a contact spot of fixed shape is in translational motion at given velocity along a line on the surface of a half-space with assigned coefficient of thermal diffusivity. A heat source of given intensity acts within the contact spot. Heat exchange with the external medium is disregarded outside the contact spot. The proposed formula approximates the exact solution of the problem in a contact spot of arbitrary shape when the ratio of the velocity of the spot to the coefficient of thermal diffusivity is large enough. The accuracy of the approximation is evaluated.
[37-6610]

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